



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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ing, Minneapolis, MN 55402 (US).(81) Designated States: AT (European patent), AU, BE (Eu-  
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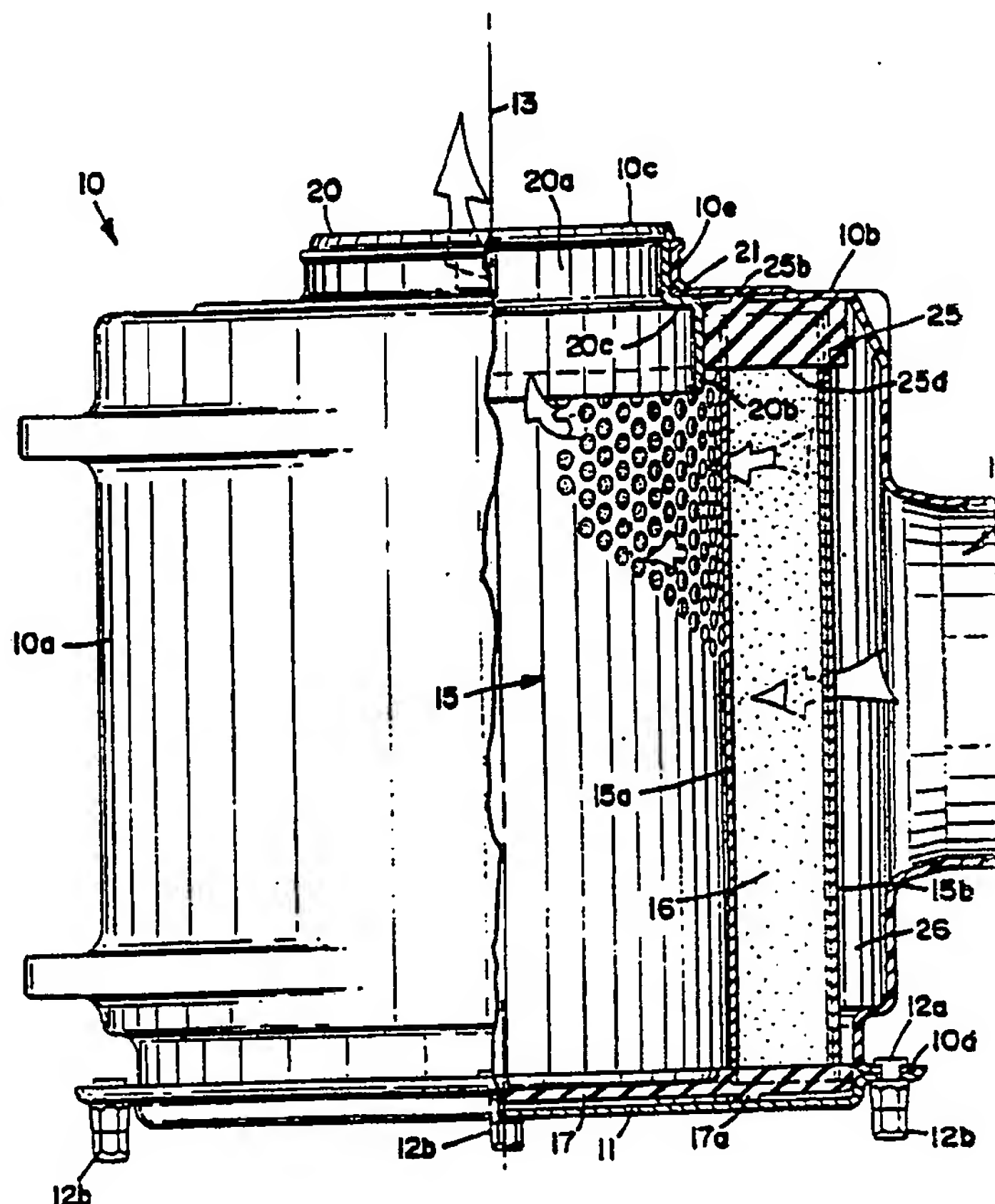
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With international search report.

(54) Title: CYLINDRICAL AIR FILTER WITH LIGHTWEIGHT HOUSING AND RADially DIRECTED SEAL.

## (57) Abstract

An air filter including a generally tubular filter element (15) having an open air outlet end and a closed end is provided with a molded ring-like end cap (25) of a soft elastomer material. A tubular air outlet member (20) is mounted in the open end of the filter element with the end cap (25) having a radially inwardly facing surface (25a) constructed so as to be compressed to sealingly engage the outlet member (20) to block flow of contaminated air therebetween. A housing (10) having an air inlet (14) surrounds the filter element to provide an air distribution chamber (26) for incoming contaminated air.



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CYLINDRICAL AIR FILTER WITH  
LIGHTWEIGHT HOUSING AND RADIALY DIRECTED SEAL

Background of the Invention

This invention relates generally to air cleaners or filters and more particularly relates to air cleaners with cylindrical, pleated paper filter elements used primarily with over-the-road trucks and agricultural tractors. In such air cleaners, the air is drawn into a housing and radially inwardly through the filter element for axial discharge therefrom. The cylindrical air filter element is sealed within the housing so that all air entering the housing must pass through the walls of the filter element.

In the prior art, sealing of the filter element in the housing has been accomplished by compressing the outlet end of the filter element against the end wall of the housing, and by providing a gasket between the end of the filter element and the housing end wall. An example of this is shown in the Anderson et al. U. S. Patent No. 3,078,650, issued February 26, 1963, in which a yoke assembly cooperating with a threaded wing bolt and nut is used to compress the filter element against the end wall of the housing to prevent leakage of air around the filter element. Various other latches and clamping devices have been used to effect a positive clean air seal in such filter assemblies. Using such state of the art axial compression sealing techniques requires filter elements constructed so as not to collapse under compression, and requires the use of relatively heavy-gauge steel in the housing to withstand the pressures. Because both the filter housing and the

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filter element must be strong and rigid when using such techniques, improvements in the area of low-cost, light-weight elements and housings have been hampered. With respect to the housings, non-engineering grades of plastics as well as some molding processes could not be safely utilized.

#### Summary of the Invention

The present invention provides an air cleaner construction wherein the positive clean air seal is established between the radially inwardly facing surface of the filter element end cap and the tubular air outlet member so that there is no need to compress the filter element as in the prior art to achieve a seal between the end of the filter element and the housing. In the preferred embodiment, this is accomplished by molding the ring-like end cap at the open end of the filter element from a urethane foam material having a relatively soft, rubber-like consistency, the cylindrical inner surface thereof being constructed and arranged to fit over and sealingly engage an inner end portion of a tubular air outlet member. A relatively lightweight housing can then be provided to channel the flow of air through the filter element. The housing can be dimensionally unstable because the housing does not have to support any clamping forces as in the prior art. No mechanical aids or clamps are necessary to exert outside force because the seal is self-generated when the end cap is inserted over the tubular outlet member, and the sealing forces are enhanced by the air pressure differential exerted on the filter element during operation.

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thereof. As a result, the housing can be constructed from a relatively light plastic material or from a thinner metal. The structural requirements of the filter element are also reduced because it does not have to withstand mechanical compression.

The Gauer U. S. Patent No. 4,135,899, issued January 23, 1979, discloses a typical prior art clamping arrangement for holding both a primary filter and a safety filter in a cylindrical housing. The safety filter of the Gauer device has an annular resilient mounting member 133 with an internal groove adapted to engage a bead on the end of the air outlet tube. However, this connection is not relied upon or designed to provide a positive clean air seal. The axially outer end of member 133 has a flattened surface to sealingly engage the end wall of the housing. The radially extending lip 134 of member 133 is compressed against the end wall of the housing by means of a clamping arrangement similar to that heretofore described. Thus, the Gauer patent does not teach or suggest the desirability of utilizing a radially inwardly directed seal in order to eliminate the clamping device.

The present invention provides the designer with a variety of inherent lightweight design options having a performance equivalent to air cleaners designed according to the state of the art. The design is compatible to non-metallic I.E. commodity (non-engineering grade) plastic housings with large expansion/contraction ratios. The lightweight plastic housing and element have good vibration dampening/absorption characteristics, further enhancing minimal housing structure requirements. Another advantage is that the gasket is located



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inside of the filter element so that it is protected during shipping and handling.

#### Brief Description of the Drawings

FIGURE 1 is a view in side elevation of an air cleaner according to the invention, portions thereof being broken away and portions being shown in section;

FIGURE 2 is a view in perspective of a filter element according to the invention, with portions of the housing being shown schematically in broken lines; and

FIGURE 3 is an enlarged fragmentary portion of the outlet area showing the tubular outlet member removed from the resilient end cap.

#### Description of the Preferred Embodiment

Referring now to the drawings, wherein like reference numerals are used throughout the several views to indicate like elements of the invention, there is disclosed in FIG. 1 an air cleaner or filter having a housing 10 with a generally cylindrical outer wall 10a, a first generally closed end 10b comprising a generally circular end wall having an axial outlet opening 10c, and a generally open second end having a circular outwardly extending flange 10d to which is connected a removable cover 11 by means of a plurality of threaded bolts 12a and plastic nuts 12b. Housing 10 is cylindrical with respect to a longitudinal axis 13. Formed in the outer wall 10a is a peripheral air inlet opening 14.

A generally tubular or cylindrical filter element 15 is carried within housing 10 coaxial therewith.

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Filter element 15 has an inner liner 15a and an outer liner 15b, both being cylindrical, and both being constructed from perforated metal. A cylindrical pleated paper filter 16 is mounted between the inner liner 15a and the outer liner 15b. Filter element 15 has a closed end 17 in the form of a circular cap of a urethane foam material molded thereon and having a relatively soft, rubber-like consistency. Cap 17 is molded over and holds together the ends of liners 15a, 15b and filter 16 and extends across that end of the filter element 15 to provide a closed end. Cap 17 has a plurality of protrusions 17a extending axially outwardly therefrom for contact with the cover 11. The diameter of housing 10 around cap 17 is about the same as the outside diameter of the cap 17 to hold filter element 15 centered within the housing.

Closed end wall 10b is provided with an axially outwardly extending tubular portion 10e around axial air outlet opening 10c. A generally cylindrical outlet member 20 is mounted in outlet opening 10c having an outer smaller diameter portion 20a and an inner larger diameter portion 20b connected by a planar ring portion 20c. The axially outer end of outer portion 20a is formed to be of slightly larger diameter to provide a wide groove between it and ring portion 20c which conforms in shape and size to the inner surface of tubular portion 10e of housing 10 so that when tubular member 20 is inserted into axial opening 10c from the interior of housing 10 the outer portion 20a thereof snaps over and snugly engages tubular portion 10e, and ring portion 20c engages the inner surface of housing end wall 10b to hold the tubular member 20 in place. The housing is

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shaped at the junction of wall 10b and tubular portion 10e to provide a circular opening for an O-ring seal 21 which functions to prevent air leakage between housing 10 and tubular member 20. When mounted in place as shown in FIG. 1, the inner portion 20b of tubular member 20 extends a short distance into the interior of filter element 15 coaxially therewith.

The open end of filter element 15, adjacent closed end 10b of the housing 10, is provided with a ring-like end cap 25 which is molded over the ends of the liners 15a, 15b and pleated paper filter 16. End cap 25 is preferably made from an elastomer such as a urethane foam material having a relatively soft, rubber-like consistency so that it is capable of functioning as a seal or gasket material. End cap 25, as shown in FIG. 3, is preferably molded so as to have a radially inwardly facing surface between the end edges thereof, most of which has a diameter slightly smaller than the outer diameter of inner portion 20b of tubular member 20. In the preferred embodiment the inwardly facing surface 25a has a diameter at the outer face 25c of end cap 25 of about the same size as the outer diameter of the tubular member 20 and a gradually reducing diameter toward the inner face 25d of end cap 25 which is less than the outside diameter of member 20. The elastomer material of end cap 25 is thus compressed at the surface 25a to provide a positive clean air seal between the end cap 25 and the outlet member 20. As also shown in FIG. 3, the innermost end of portion 20b is formed to have a slightly smaller diameter so that end cap 25 can easily be inserted over portion 20b. End cap 25 thus has a generally cylindrical inner surface 25a of gradually



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reducing diameter from outside to inside constructed and arranged to fit over and sealingly engage the inner portion 20b of outlet member 20 to thus provide a positive air seal between the end cap 25 and inner portion 20b of outlet member 20.

End cap 25 is also provided with a plurality of axially outwardly extending, arcuate projections or protrusions 25b which engage end wall 10b to hold the filter element in place. The relationship between end cap 25 and tubular outlet member 20 maintains filter element 15 in a coaxial relationship with housing 10 at the outlet end of the air cleaner.

The distance between closed end 10b of housing 10 and cover 11 is such as to lightly compress the projections or protrusions 17a, 25b to minimize or dampen axial movements of filter element 15 in the housing 10.

With the air cleaner assembled as shown in FIG. 1, the engine draws air through the filter assembly from housing inlet 14 into a distribution chamber 26 formed between outer wall 10a and outer liner 15b. The contaminated incoming air is thus distributed generally evenly over the outer surface of filter element 15 and is drawn through the pleated paper filter 16 into the interior of filter element 15 for discharge through outlet opening 10c. All of the foreign material carried by the incoming air is thus deposited on the pleated paper filter 16. It is important that all of the incoming air be passed through the filter, because if the dirty incoming air is permitted to escape around the filter, the engine may be damaged. The dirty air cannot escape around the filter at the closed end because that end is completely covered by cap 17. At the air outlet

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end of the housing, however, it is necessary to provide a seal between the filter element 15 and the housing 10 to prevent leakage therebetween. In the present case, that seal is provided by the tight engagement of inner peripheral wall 25a of gasket 25 with the outer peripheral wall of portion 20b of tubular outlet member 20. This sealing relationship is enhanced by the pressure differential between the inlet and outlet of the air cleaner during operation of the system. Because a positive clean air seal is achieved as just described, there is no need to clamp the filter element 15 tightly against the end wall 10b. Thus, no expensive clamping devices are required, and only light pressure against the ends of the filter element need be maintained to minimize movement within the housing. In the preferred embodiment as shown in the drawings, the housing 10 is constructed from a commodity grade plastic material. Such a material would ordinarily not be strong enough to provide the axial compression sealing required by the prior art techniques. With the present sealing technique, however, such strength is not required, so that a lesser material can be used for the housing. In the embodiment of the invention shown in the drawings, a standard filter element has been shown because that construction is available. The standard filter element 15 uses relatively heavy perforated metal liners 15a, 15b in order to withstand the standard compression sealing techniques. However, it should be understood that the structure of the filter element might also be modified as development of this invention progresses because the same strength and rigidity is not required using the new sealing technique. The filter element

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must be strong enough to withstand the pressures caused by air flow therethrough, but it is no longer necessary to withstand the axial compression forces.

Although a preferred embodiment of the invention has been disclosed, it will be understood that the same is capable of modification without departure from the scope and spirit of the invention as defined in the claims.

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## WHAT IS CLAIMED IS:

1. An air filter, comprising:
  - (a) a generally tubular filter element comprising a filter having an open air outlet end and a closed end;
  - (b) said open end of said filter element having an end cap of a soft rubber-like material;
  - (c) housing means including a tubular air outlet member extending into said open end of said filter element, said end cap having a radially inwardly facing surface constructed and arranged to be compressed to sealingly engage said air outlet member to block flow of contaminated air therebetween; and
  - (d) said housing means surrounding said filter element to provide an air distribution chamber around said filter element, and having an air inlet opening to provide a flow of air to said distribution chamber and through said filter element.
2. The air filter of claim 1 wherein said filter element includes a supporting liner and said end cap is ring-like and is constructed and arranged to be compressed between said air outlet member and said liner.
3. The air filter of claim 2 wherein said radially inwardly facing surface has at least a portion thereof with an inside diameter smaller than an outer diameter of said air outlet member whereby said rubber-like material is compressed to provide a positive clean air seal between said end cap and said outlet member.

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4. The air filter of claim 3 wherein said end cap has an outer face and an inner face with said radially inwardly facing surface extending therebetween to define said air outlet, said air outlet at said outer face having a diameter of about the same size as said outlet member, said air outlet at said inner face having a smaller diameter, said radially inwardly facing surface being gradually reduced in diameter therebetween.

5. The air filter of claim 1 wherein said end cap is an elastomer material, and wherein said tubular air outlet member, extending into said open end of said filter element has a first outer diameter, said end cap defining an opening having a radially inwardly facing surface with a diameter smaller than said first diameter, and constructed and arranged to be compressed to sealingly engage said air outlet member to block flow of contaminated air therebetween.

6. The air filter of claim 1 wherein:

(a) said housing means comprises a lightweight housing having a longitudinal axis, a first generally closed end having an axial outlet opening, a generally open second end closeable by a removeable cover, and a peripheral air inlet opening;

(b) said filter element is a generally cylindrical filter element comprising an inner liner, a filter and an outer liner, carried within said housing coaxial therewith, having a first end engageable with said closed end of said housing and having a second, closed end engageable with said cover;



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- (c) said closed end of said housing comprises a cylindrical air outlet member in said outlet opening having a short inner portion extending axially inwardly into said housing and said filter element, said inner portion having a first outside diameter; and
- (d) said first end of said filter element comprising said ring-like end cap, said end cap having a generally cylindrical radially inwardly facing surface of a diameter smaller than said first diameter and constructed and arranged to fit over said inner portion of said outlet member and to be compressed between said inner portion and said inner liner to sealingly engage said inner portion of said outlet member whereby air flowing from said air inlet into said housing is forced to flow through said filter element to said outlet opening.

7. The air filter of claim 6 wherein said end cap includes a plurality of projections extending axially therefrom for engagement with said closed end of said housing.

8. The air filter of claim 7 wherein said closed end of said filter element comprises a cap having a consistency like that of said end cap, extending over and closing said closed end of said filter element, said cap having a plurality of projections extending axially therefrom for engagement with said cover.

9. The air filter of claim 8 wherein the distance between said closed end of said housing and said cover is

-13-

such as to lightly compress said projections and said cap to minimize movement of said filter in said housing.

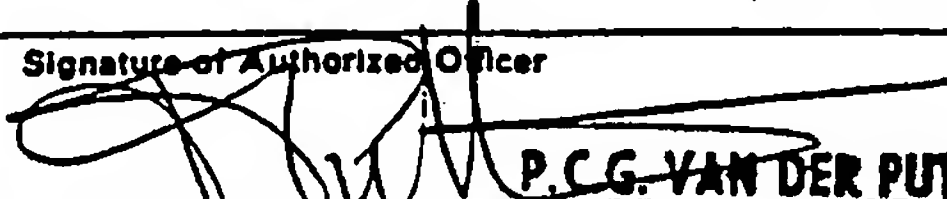
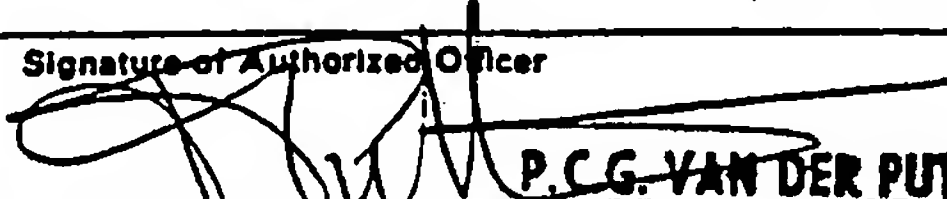
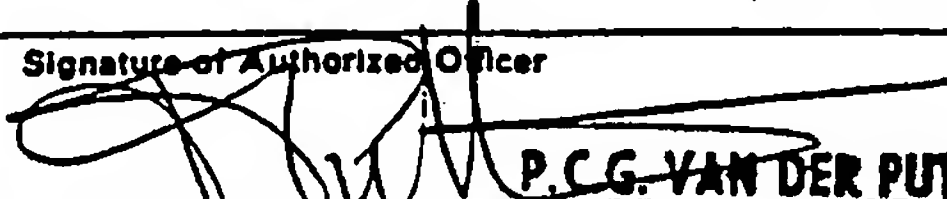
10. The air filter of claim 9 wherein said end cap and said cap are molded from an elastomer material.

11. The air filter of claim 10 wherein the elastomer material is a urethane foam.



# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 87/02232

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC <sup>4</sup> :     B 01 D 46/24; F 02 M 35/024																							
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Minimum Documentation Searched <sup>7</sup></div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 30%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px;">IPC<sup>4</sup></td> <td style="padding: 5px;">B 01 D; F 02 M</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup></div>			Classification System	Classification Symbols	IPC <sup>4</sup>	B 01 D; F 02 M																	
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IPC <sup>4</sup>	B 01 D; F 02 M																						
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category <sup>9</sup></th> <th style="border-bottom: 1px solid black;">Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup></th> <th style="width: 15%; border-bottom: 1px solid black;">Relevant to Claim No. <sup>13</sup></th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">FR, A, 1131647 (KNECHT) 25 February 1957 see page 2, left-hand column, paragraphs 2-5; figure 1 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-3,5,6</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">US, A, 4135899 (GAUER) 23 January 1979 see figure 1; column 1, lines 50-58, 65-68; column 2, lines 1-14, 29-38, 59-66 cited in the application --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-3,5,6</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">FR, A, 1100273 (FRAM) 19 September 1955 see page 1, right-hand column, last 9 lines; page 2, left-hand column, lines 1-3,14-30; figures 1,4 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">7-9</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">US, A, 4491460 (TOKAR) 1 January 1985 see column 3, lines 1-13 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">10,11</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">GB, A, 2005777 (DONALDSON) 25 April 1979 see page 2, lines 91-92, 103-130; page 3, lines 1-18, 45-51 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="text-align: center; vertical-align: top; padding: 5px;">-- ./.</td> <td style="text-align: center; vertical-align: top; padding: 5px;">2-5</td> </tr> </table>			Category <sup>9</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	Y	FR, A, 1131647 (KNECHT) 25 February 1957 see page 2, left-hand column, paragraphs 2-5; figure 1 --	1-3,5,6	Y	US, A, 4135899 (GAUER) 23 January 1979 see figure 1; column 1, lines 50-58, 65-68; column 2, lines 1-14, 29-38, 59-66 cited in the application --	1-3,5,6	A	FR, A, 1100273 (FRAM) 19 September 1955 see page 1, right-hand column, last 9 lines; page 2, left-hand column, lines 1-3,14-30; figures 1,4 --	7-9	A	US, A, 4491460 (TOKAR) 1 January 1985 see column 3, lines 1-13 --	10,11	Y	GB, A, 2005777 (DONALDSON) 25 April 1979 see page 2, lines 91-92, 103-130; page 3, lines 1-18, 45-51 --	1	A	-- ./.	2-5
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A	-- ./.	2-5																					
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>																							
<b>IV. CERTIFICATION</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="text-align: center; padding: 5px;">29th April 1988</td> <td style="text-align: center; padding: 5px;">09 JUN 1988</td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;">International Searching Authority</td> <td style="border-bottom: 1px solid black; padding: 5px;">Signature of Authorized Officer</td> </tr> <tr> <td style="text-align: center; padding: 5px;">EUROPEAN PATENT OFFICE</td> <td style="text-align: center; padding: 5px;">             P.C.G. VAN DER PUTTEN         </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	29th April 1988	09 JUN 1988	International Searching Authority	Signature of Authorized Officer	EUROPEAN PATENT OFFICE	 P.C.G. VAN DER PUTTEN													
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29th April 1988	09 JUN 1988																						
International Searching Authority	Signature of Authorized Officer																						
EUROPEAN PATENT OFFICE	 P.C.G. VAN DER PUTTEN																						

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4227898 (KAMEKAWA) 14 October 1980 see figures 4,6; column 2, lines 41-68; column 3, lines 1-15	1
A	BE, A, 545333 (DESMULIE) 9 October 1959 see page 8, last 13 lines; page 9, lines 1-7; figure 10	1,3,5
A	DE, C, 671029 (BOSCH) 30 January 1939 see figure 1; page 1, lines 52-53	2
A	FR, A, 1291243 (FRAM) 12 March 1962 see page 2, left-hand column, lines 40-45, 56-58 and right-hand column, lines 1-21,30-35	1,3,4,7-9
A	FR, A, 2268551 (C.F.E.A.) 21 November 1975 see page 5, lines 39-40; page 6, lines 1-23	1,3
A	FR, A, 2261041 (C.F.E.A.) 12 September 1975 see page 1, lines 1-8; page 3, lines 16- 40; page 4, lines 1-2; page 6, lines 3- 22	1,3,5,7-11
A	FR, A, 2214505 (C.F.E.A.) 19 August 1974 see page 5, lines 22-35	1
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# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

US 8702232

SA 18732

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 24/05/88. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A- 1131647		None	
US-A- 4135899	23-01-79	FR-A, B 2391761	22-12-78
		DE-A, C 2819198	30-11-78
		JP-A- 54034182	13-03-79
		AU-B- 509602	15-05-80
		AU-A- 3565378	08-11-79
		GB-A- 1602399	11-11-81
		CA-A- 1118369	16-02-82
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